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Research article/Araştırma makalesi

Determination of important plant characteristics in summer savory (*Satureja hortensis* L.) by some statistical methods

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Abstract

The aim of this study is to determine the effectiveness of plant characteristics on dry leaf weight by different statistical methods and to lead breeders to determine the effect of plant characteristics and which of plant characteristics could be efficiently used in breeding programs. Seeds of *S. hortensis* genotypes were obtained from Black Sea Agricultural Research Institute. Analysis of six statistical analyses stressed that auxiliary branch number, wet plant weight, dry plant weight and wet leaf weight are found as the most important and efficacious characters for dry leaf weight in summer savory. Such characters could be used to guide future breeding studies and management of summer savory genotypes. Besides, they will create opportunity to increase success of selection summer savory improvement programs and to develop high yielding genotypes with high drug quality.

Key words: *Satureja hortensis*), plant characteristics, statistical methods, genotype

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Sater bitkisinde (*Satureja hortensis* L.) bazı istatistik metotlar kullanılarak önemli bitkisel karakterlerin belirlenmesi

Özet

Bu araştırmada bazı istatistik metotları kullanılarak sater ıslah programlarında çeşit geliştirmede etken olacak önemli bitkisel karakterlerin belirlenmesi amaçlanmıştır. Çalışmada kullanılan sater tohumları Karadeniz Tarımsal Araştırma Enstitüsü Müdürlüğü'nden temin edilmiştir. Bitki kuru yaprak verimi bağımlı değişken alınarak, incelenen diğer özelliklerin kuru yaprak verimi üzerine etkisi değerlendirilmiştir. Araştırma sonuçlarına göre; yan dal sayısı, yaş bitki ağırlığı, kuru bitki ağırlığı ve yaş yaprak ağırlığının kuru yaprak ağırlığı üzerine etkili olan unsurlar olduğu, bu unsurların kullanılmasıyla başarılı bir sater ıslah programının yürütülebileceği, ve yüksek drog kalitesine sahip çeşit geliştirilebileceği sonucuna varılmıştır.

Anahtar kelimeler: *Satureja hortensis*, bitki unsurları, istatistiki metotlar, genotip

1. Introduction

Summer savory (*Satureja hortensis* L., Lamiaceae) is one of the well-known medicinal and aromatic plants that is native to Southern Europe, Anatolia, Caucasus, Iraq and western Iran, and is recently cultivated for tea or additive in commercial spice mixtures for many foods to offer aroma, flavor drink and perfume industries in many parts of the world (Sifola and Barbieri, 2006; Mumivand et al., 2011 and Macit and Köse, 2015). Besides, economic value of this crop depends on the drug leaf yield, essential oil yield and essential oil content as well as the concentration of carvacrol and γ-terpinene in the essential oil (Mumivand et al., 2011).

S. hortensis plant is native to İstanbul, Sakarya, Zonguldak, Amasya, Samsun, Ankara, Nevşehir, Sivas, Erzincan, Adıyaman, Adana, Diyarbakır, Samsun, Tokat and Erzurum provinces of Turkey (Davis 1982; Muca et.al., 2012). Though, *S. cuneifolia* Ten., *S. thymbra* L., *S. hortensis* L., *S. spicigera* (K.Koch) Boiss. are also gathered for

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commercial purpose (7000–8000 t/ha per year) in Meditteranean and Egean regions in Turkey; this plant is mostly uncontrolled and extensively gathered and traded by seed is under thread of extinction. (Satıl et al. 2008). Controlled gathering of plant from the nature and their planned initiation of breeding programs are necessary to preserve evanescence of them and to develop novel high yielding and quality genotypes. Besides, further studies are needed to determine optimum agronomic practices and to reveal the major plant characteristics that are effective on dry leaf weight. Determining main plant characteristics will give opportunity to success of breeding and agronomic programs (Andi et al., 2011 and Macit and Köse, 2015). There are various statistical techniques covering correlation, regression, cluster, path, factor analyses to evaluate yield and plant characteristics for success of breeding programs (Massart et al., 1997; Özdamar, 1999; Ekiz, et al., 2006; Andi et al., 2011). The aim of this study is to determine the effectiveness of plant characteristics on dry leaf weight by different statistical methods and to lead breeders to determine the effect of plant characteristics and which of plant characteristics could be efficiently used in breeding programs.

2. Materials and methods

The experiments were carried out at the experimental field of the University of Eskişehir Osmangazi, Faculty of Agriculture, Department of Field Crops (39º 46′ N, 30º 32′ E, 732 m above sea level) during the crop growing period of 2014 and 2015. Meteorological data for the growing seasons are shown in Table 1.

Table 1. Rainfall, air temperature and relative humidity during vegetation of *Satureja hortensis* in 2014 and 2015 in comparison with multi-year period (1960-2015)

ESKISEHIR	Years	April	May	June	July	Total/Mean
Average Temperature (°C)	1960-2012	10.2	15.1	19.1	21.7	16.53
	2014	11.5	15.1	18.5	22.6	16.93
	2015	7.9	15.5	17.1	22.1	15.65
The highest temperature (°C)	1960-2012	16.8	21.8	25.9	28.9	23.35
	2014	26.6	28.9	34.9	36.4	31.70
	2015	26.3	30.8	28.2	37.2	30.63
The lowest temperature (°C)	1960-2012	3.7	7.8	11.2	13.8	9.13
	2014	-3.7	3.8	6.9	10.2	4.30
	2015	-4.7	3.3	6.1	10.1	3.70
Monthly of rainfall (mm)	1960-2012	43.4	44.4	31.0	13.2	132.0
	2014	15.2	27.2	70.6	7.5	120.5
	2015	26.6	47.8	151.1	-	225.5

Source: Eskişehir Meteoroloji Bölge Müdürlüğü.

Meteorological data for the growing seasons of years are shown in Table 1. During the growing periods (from April to July) total precipitation, average, minimum and maximum temperatures were 120.5 mm, 16.93°C, 31.70°C and 4.30°C in 2014; 225.5 mm, 15.65°C, 30.63°C and 3.7°C in 2015; 132.0 mm, 16.53°C, 23.35°C and 9.13°C in long-term period (1960-2012), respectively. Total precipitation was lower in 2014 and higher in 2015 than long-term period (Table 1). Soil samples from a depth of 30 cm were taken before starting the experiment, and were subjected to a physicochemical analysis and are shown in Table 2.

Table 2. Some physical and chemical characteristics of the soil of experimental site.

Structure	Depth of soil samples (cm)	pH	Salt (%)	Lime (%$CaCO_3$)	Organic matter (%)	Plant-available	
						P_2O_5 (kg/da)	K_2O (kg/da)
Loamy (2014)	0-30	7,82	0,020	6,62	2,41	5,49	209,33
Loamy (2015)	0-30	7,10	0,041	5,23	1,6	4,98	223,1

Soils from the growing periods of trial years had organic matter concentrations of 2.41% and 1.6%, low P_2O_5 (5.49 and 4.98 kg da^{-1}), medium K_2O (209.33 and 223.1 kg da^{-1}), an alkaline pH (7.82 and 7.1), a salt content of 0.020 and 0.041% and a $CaCO_3$ content 6.62 and 27.1%, respectively (Table 2).

Seeds of *S. hortensis* genotypes were obtained from Black Sea Agricultural Research Institute. These seeds were sown in pots containing sand and torf material (1:1) in greenhouse conditions in 14.03.2014 and 10.03.2015. Pots were regularly watered and weeds were removed by hand when needed. Once seedlings reached 5 cm plant height (1,5 month later) plants in the pots were transplanted to experimental plots having 45 cm between rows and 20 cm within rows (Katar et al., 2011). Experiment were carried out in randomized complete block design with 3 replications (experimental plots 6 m x 2,70 m = 16,20 m^2, 6 row and 144 plant/plot). Drop irrigation was applied and used during the growing period when needed. Plants were harvested at 40-50% of flowering period (10.07.2014 and 15.08.2015) by pruning shears 4-5 cm above the ground (Katar et al., 2011). Fresh drug values were weighed by precision scales. Fresh leaf values were also determined by weighting leaves of plants which were used for fresh drug weight. Fresh leaves were dried at 35 ^oC ±2 temperature in stove for 24-30 hours and weighted; in this way, drug leaf yields were determined. Different statistical programs were used for correlation (SAS), path (TARIST), multiple regression, best subset regression, cluster (MINITAB 17) and factor (SPSS 21) analyses. Data of plant characters over the two years in the study were evaluated by statistical procedures; correlation, the multiple and best subset regression analyses, path analysis, cluster analysis and factor analysis..

3. Results

S. hortensis is herbal plant the importance of herbal raw materials in plant is increasing, since their use is increasing as ingredients of herbal teas, dietary supplements, and natural food additives (Wills et al. 2000; Alizadeh et al., 2010; Andi et al., 2011). Yielding performance and biological value of herbs of *S. hortensis* are very diverse depending upon responses of plant to growing conditions (position, soil, temperature, precipitation), as well as the methods of cultivations (Mumivand et al., 2011). Crop yield is weight of harvested economic product per unit area and The yield components and their activities involved in their responses to the crop growth environment, management practices, and pests to affect yield performance (Telci and Hisil, 2008). Analysing interactions between yield and yield components are more likely to improve the success of breeding programs by determining and effectively using criteria for developing novel Summer savory genotypes.

3.1. Correlation analysis

Assigning strength of relationship between two variables, correlation analysis is useful analysis and is widely used on data evaluations plant studies (Özdamar, 1999). Minimum, maximum, mean of all characters in summer savory genotypes are shown in Table 3. Besides, correlations between characters and probability plots and comparisons of distributions in characters are shown in Figure 1.

Table 3. Minimum, maximum, mean of characters of summer savory genotypes

Characters	Mean	Minimum	Maximum
Plant Height	32.77±0.21	26.00	37.50
Auxiliary Branch Number	20.74±0.13	17.36	23.71
Habitus Diameter	26.39±0.42	16.00	36.00
Wet Plant Weight	123.47±3.60	47.30	198.50
Dry Plant Weight	28.57±0.15	10.86	50.33
Wet Leaf Weight	64.67±1.02	29.76	91.25
Dry Leaf Weight	1843.92±47.61	858.93	2680.28

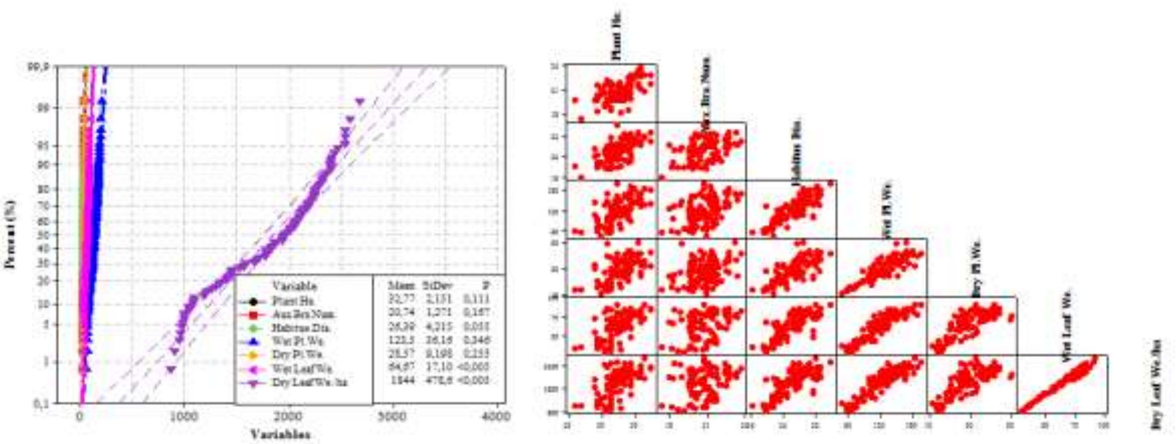

Figure 1. Correlations between characters and probability plots and comparisons of distributions in summer savory

If correlation value close to 1, it indicates almost identically behaving of two characters. Moreover, if value close to -1, this assign opposite manner, and a value close to 0 shows independent behavior in two characters (Acevedo et al., 1989; Özdamar, 1999; Hiltbrunner et al., 2007). Table 3 shows that all characters have positive and significant relationships with each other. Researches stressed that, considerably important innovations could be possible in breeding programs when use of characters having significant correlations are given; and this could lead to improve target yield, to accelerate emerging the novel genotypes (Acevedo et al., 1989; Hiltbrunner et al., 2007).

Table 4. Correlation matrix of characters in of summer savory genotypes

	DryLe.We.	Plant He.	Aux.Br.Nu.	Hab.Dia.	Wet Pl.We.	Dry Pl.We.
Plant He.	**0.660****					
Aux.Br.Nu.	**0.294****	**0.605****				
Hab.Dia.	**0.787****	**0.667****	**0.432****			
Wet Pl.We.	**0.905****	**0.677****	**0.435****	**0.834****		
Dry Pl.We.	**0.790****	**0.613****	**0.395****	**0.765****	**0.884****	
Wet Le.We.	**0.986****	**0.676****	**0.335****	**0.815****	**0.915****	**0.814****

3.2. Multiple Linear Regression Analysis

The aim of multiple linear regression analysis is to determine and modelling of relationship between dependent variable and one or more independent predictors. Regression analysis specifies individual effects of independent factors on dependent factor. Strength of model is heavily depends on effectiveness and number of components considered on yield. (Frank and Friedman, 1993; Andales et al., 2007 and Alizadeh et al., 2010). Multiple linear regression analysis is given in Table 5.

Table 5. Multiple linear regression analysis having regression coefficient (*b*), standard error (SE), *T*-value and p-value of the characters in estimation of dry leaf weight

Analysis of Variance				
Source	**Deg of Freedom**	**Sum of Squares**	**Means of Squares**	**F_{values}**
Regression	6	22364921	3727487	649,58**
Residual Error	94	539403	5738	
Total	100	22904323		
Predictor		**Coeff.of Reg (B)**	**St.Er.of Coef.**	**T_{values}**
Plant Height		6,804	5,763	1,18ns
Auxiliary Branch Number		-20,150	7,896	-2,55*
Habitus Diameter		-5,795	3,462	-1,67ns
Wet Plant Weight		1,5301	0,6841	2,24*
Dry Plant Weight		-2,871	1,770	-1,62ns
Wet Leaf Weight		26,996	1,205	22,41**
R²:97,6%	**Dry Leaf Weight =** 339+6,80***Plant Height**-20,2***Auxilaary Branch Number**-5,80***Habitus Diameter**+1,53***Wet Plant Weight**-2,87***Dry Plant Weight**+27,0***Wet Leaf Weight**			

Regression analysis is the safe method o make crop yield prediction (Massart et al., 1997). Andales et al. (2007) precisely predicted crop yield by linear regression model. Yield estimation formula, developed by using variables, is shown below:

The regression equation is;

Dry Leaf Weight = 339+6,80***Plant Height**-20,2***Auxilaary Branch Number**-5,80***Habitus Diameter**+1,53***Wet Plant Weight**-2,87***Dry Plant Weight**+27,0***Wet Leaf Weight**

This formula explains 97.6% variation in variables and the remaining 2.4% shows residual effects. Table 4 shows that auxiliary branch number, wet plant weight and wet leaf weight have the greatest effect in dry leaf weight; and they are important variables and should be used in bread summer savory breeding programs.

3.3. Best subsets regression

Determining the best-fitting regression models this model is an active method to determine models achieving the most effective predictors. This model evaluates subsets of the predictors, starting from all models having one predictor, and then all models having two predictors etc. and this also shows the two best models for each number of predictors (Hocking, 1976; Montgomery and Peck, 1982; Frank and Friedman, 1993; Buhlmann and Hothorn, 2007; Buhlmann and van de Geer, 2011). Best subset regression analysis showing best subsets-the most effective predictors for dry leaf weight are given in Table 6. Table 6 shows that four variables have the higher adjusted R with 97.6%, low Mallow’s Cp value (5,7), and the lowest S value (74.42). This model, considered with the minimum fit, has the best four-predictor model including auxiliary branch number, wet plant weight, dry plant weight and wet leaf weight.

Table 6. Best subset regression analysis showing best subsets-the most effective predictors for dry leaf weight in summer savory genotypes

Variables	R^2	Mallows		1*	2	3	4	5	6
	(Adj.)	Cp	S						
1	97.3	10.9	79.10						✓
1	81.8	628.5	205.06				✓		
2	97.4	9.3	77.33		✓				✓
2	97.4	9.3	78.13			✓			✓
3	97.5	7.5	77.11		✓	✓			✓
3	97.5	7.9	77.24		✓		✓		✓
4	97.6	5.7	74.42		✓		✓	✓	✓
4	97.5	7.0	76.53		✓	✓	✓		✓
5	97.6	6.4	75.91		✓	✓	✓	✓	✓
5	97.6	7.6	76.40	✓	✓	✓	✓		✓
6	97.6	7.0	75.75	✓	✓	✓	✓	✓	✓

***1:** Plant height, **2:** Auxilary branch number, **3:** Habitus diameter, **4:** Wet plant weight, **5:** Dry plant weight, **6:** Wet leaf weight.

Our findings are similar to the results of studies that best model should has efficient predictors having highest adusted R^2, smallest Cp and S; and the number of fertile tillers and the number of grains per spike are the important traits in showing the yield in the barley genotypes (Abdullahi et al., 2010 and Zaefizadeh et al., 2011).

3.4. Factor Analysis

This analysis is an efficacious tool assigning specific factors, and explicate correlations in variable data; it is also reveals relationships in variables for complex concepts such as yield components. The purpose of this method is to summarize the data of covariance structure in a few dimensions of the data. Factors contain a number of variance in variables observed, and they show amount of variation explained (Austin and Lee, 1996). Factor analyses of characters are given in Table 7. Table 7 shows that three main factors are defined in groups for 88.13% of total variability in the dependent variable. The first, the second and the third factors are constituted of 74.22%, 13.43% and 0.48%, respectively. The first factor shows 74.22% of total variability in the dependent value and this factor primarily comprises wet leaf weight, wet plant weight, habitus diameter. The proposed variable is wet leaf weight. The second and the third factors show 13.43% and 0.48% of total variability in the dependent value. These factors include auxiliary branch number and plant height in the second factor, dry plant weight in third factor. Proposed characters for factor 2 and 3 are auxiliary branch number and dry plant weight (Table 6). Factor analysis shows that, wet leaf weight, auxiliary branch number and dry plant weight have the highest communality and higher contribution dry leaf weight in *S. hortensis* genotypes.

Table 7. Rotated (varimax rotation) factor communalities for the estimated characters and summary of factors loading for characters in summer savory genotypes

Characters	$Factor_1$	$Factor_2$	$Factor_3$	Communality
Plant Height	0.803	0.363	-0.328	0,644
Auxiliary Branch Number	0.532	0.807	0.0195	0,283
Habitus Diameter	0.894	-0.039	0.068	0,798
Wet Plant Weight	0.927	-0.120	0.116	0,916
Dry Plant Weight	0.891	-0.119	0.478	0,794
Wet Leaf Weight	0.958	-0.230	-0.079	0,895
Latent Roots	5.192	0.936	0.335	7.248
Factor Variance (%)	74.22	13.43	0.48	88.13

	Loading	% Total Communality	Suggested Factor Name
	$Factor_1$	74.22	
Wet Leaf Weight	0.958		**Wet Leaf Weight**
Wet Plant Weight	0.927		
Habitus Diameter	0.894		
	$Factor_2$	13.43	
Auxiliary Branch Number	0.807		**Auxiliary Branch Number**
Plant Height	0363		
	$Factor_3$	0.48	
Dry Plant Weight	0.478		**Dry Plant Weight**
Cumulative Variance		88.13	

3.5. Cluster Analysis

Cluster analysis is an agglomerative hierarchical method and also classifies variables into groups and to cluster variables for reducing their number. The aim is to reduce the number of variables by combining variables with similar characteristics. Clustering of variables is made with the default correlation distance measure, average linkage and dendogram (Press and Wilson, 1978; Milligan, 1980; Rencher, 1995). Number of steps and clusters, correlation coefficient distance, average linkage and amalgamation steps for plant characteristics of summer savory genotypes are given in Table 8. Step three with high similarity, low distance level between them, assigns three clusters having different similarities between characters. Besides, the dendrogram in Figure 2 displays the information of characters given in Table 8 in the form of a tree diagram.

Table 8. Number of steps and clusters, correlation coefficient distance, average linkage and amalgamation steps for plant characteristics of *S. hortensis* genotypes

Step	No of Clusters	Similarity Level	Distance Level	Clusters Joined	
1	6	99.321	0.013	6	7
2	5	95.773	0.084	4	6
3	4	95.174	0.116	3	5
4	3	91.683	0.165	3	4
5	2	83.842	0.323	1	3
6	1	80.262	0.394	1	2

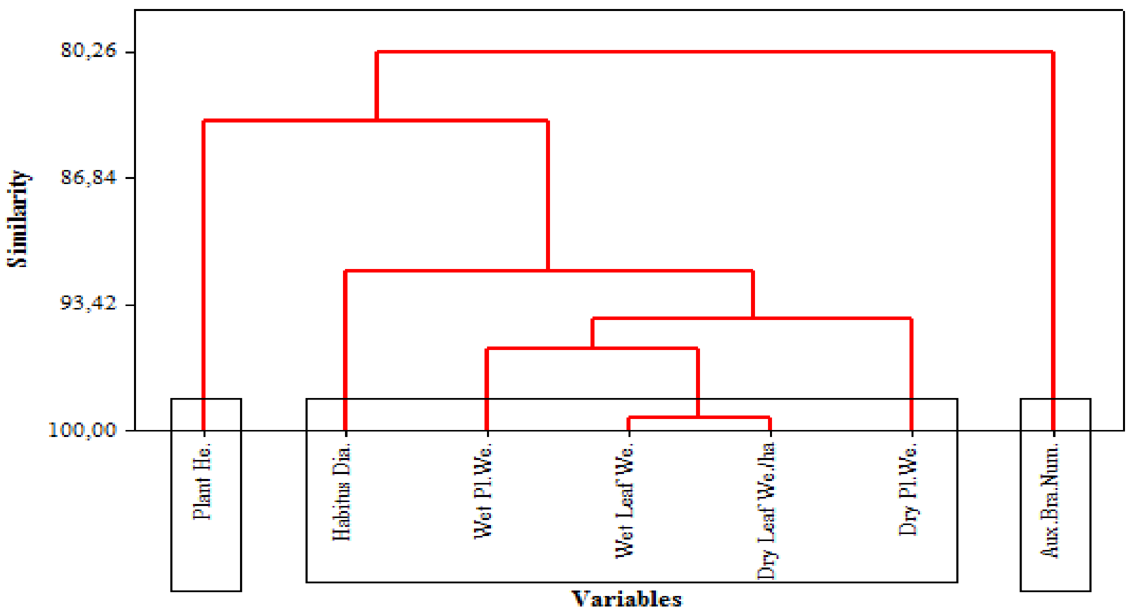

Figure 2. Cluster of characters having different similarities in between characters *S. hortensis* genotypes

Figure 2 shows that plant height and auxiliary branch number occupy separate groups; habitus diameter, wet plant weight, dry plant weight, wet leaf weight and dry leaf weight joined same group. Cluster analysis reveals habitus diameter, wet plant weight, dry plant weight, wet leaf weight are efficient characters on dry leaf weight.

3.6. Path Analysis

As a simplistic extension of multiple regression, this analysis aims to determine estimates of the magnitude and significance of hypothesized causal connections between sets of variables. Moreover, path analysis is effective and convenient method for explaining dependent variable and explains well degrees of direct and indirect effects of yield components on yield (Topal et al., 2004). Studies stressed that some yield components such as number of grain per spike, grain weight and number of spikes per unit area had direct and positive effect on grain yield in bread wheat (Mollasadeghi et al., 2011; Shamsi et al., 2011).

Table 9. Path coefficients (direct and indirect effects) of characters affecting dry leaf weight in *S. hortensis*

		Direct Effect		Correlation Coefficient
Plant Height		**Path Coefficient**	**%**	**0.660****
		0.0306	3.5515	
		Indirect Effects		
		Path Coefficient	**%**	
via	**Auxiliary Branch Number**	-0.0324	3.7616	
	Habitus Diameter	-0.0340	3.9548	
	Wet Plant Weight	0.0783	9.0896	
	Dry Plant Weight	-0.0338	3.9317	
	Wet Leaf Weight	0.6518	75.7109	
		Direct Effect		**Correlation Coefficient**
Auxiliary Branch Number		**Path Coefficient**	**%**	**0.294****
		-0.0535	10.9395	
		Indirect Effects		
		Path Coefficient	**%**	
via	**Plant Height**	0.0185	%3.7834	
	Habitus Diameter	-0.0220	%4.5044	
	Wet Plant Weight	0.0502	%10.2722	
	Dry Plant Weight	-0.0218	%4.4536	
	Wet Leaf Weight	0.3230	%66.0468	
		Direct Effect		**Correlation Coefficient**
Habitus Diameter		**Path Coefficient**	**%**	**0.787****
		-0.0510	5.0064	
		Indirect Effects		
		Path Coefficient	**%**	
via	**Plant Height**	0.0204	2.0006	
	Auxiliary Branch Number	-0.0231	2.2656	
	Wet Plant Weight	0.0964	9.4554	
	Dry Plant Weight	-0.0422	4.1429	
	Wet Leaf Weight	0.7863	77.1291	
		Direct Effect		**Correlation Coefficient**
Wet Plant Weight		**Path Coefficient**	**%**	**0.905****
		0.1156	10.1991	
		Indirect Effects		
		Path Coefficient	**%**	
via	**Plant Height**	0.0207	1.8252	
	Auxiliary Branch Number	-0.0232	2.0508	
	Habitus Diameter	-0.0425	3.7531	
	Dry Plant Weight	-0.0488	4.3012	
	Wet Leaf Weight	0.8828	77.8705	
		Direct Effect		**Correlation Coefficient**
Dry Plant Weight		**Path Coefficient**	**%**	**0.790****
		-0.0552	5.4048	
		Indirect Effects		
		Path Coefficient	**%**	
via	**Plant Height**	0.0188	1.8363	
	Auxiliary Branch Number	-0.0211	2.0681	
	Habitus Diameter	-0.0391	3.8249	
	Wet Plant Weight	0.1022	10.0045	
	Wet Leaf Weight	0.7849	76.8614	
		Direct Effect		**Correlation Coefficient**
Wet Leaf Weight		**Path Coefficient**	**%**	**0.986****
		0.9643	80.6762	
		Indirect Effects		
		Path Coefficient	**%**	
via	**Plant Height**	0.0207	1.7289	
	Auxiliary Branch Number	-0.0179	1.4995	
	Habitus Diameter	-0.0416	3.4816	
	Wet Plant Weight	0.1059	8.8557	
	Dry Plant Weight	-0.0449	3.7580	

Correlations in summer savory are separated as direct and indirect effects in Table 9. Direct effect of plant height on dry leaf weight is 3.5515% (0.0306), the highest indirect effects of it are via wet leaf weight (75.7109%, 0.6518) and wet plant weight (9.0896%, 0.0783). In auxiliary branch number, the highest indirect effects of auxiliary branch number are via wet leaf weight (66.0468%, 0.3230) and wet plant weight (10.2722%, 0.0502); direct effect of it on dry leaf weight is 10.9395% (-0.0535).

Negative direct effect belongs to habitus diameter (5.0064%, -0.0510), and similarly the highest indirect effects of habitus diameter are via wet leaf weight (77.1291%, 0.7863) and wet plant weight (9.4554%, 0.0964). Wet plant weight have low direct effect (10.1991%, 0.1156), but the highest indirect effect of wet plant weight belongs to wet leaf weight (77.8705%, 0.8828). Meanwhile, direct effect of dry plant weight on dry leaf weight is 5.4048% (-0.0552), the highest indirect effects of dry plant weight are via wet leaf weight (76.8614%, 0.7849) and wet plant weight (10.0045%, 0.1022). Wet leaf weight have the highest direct effect on dry leaf weight with 80.6762% and 0.9643, the highest indirect effects of it is for wet leaf weight with 8.8557%, 0.1059. Dispersion of direct and indirect effects of characters on dry leaf weight are shown in Figure 3. As shown, wet leaf weight and wet plant weight have the highest direct effect and wet leaf weight also have the highest indirect effect. So, wet leaf weight and wet plant weight are the most efficient characters on dry leaf weight.

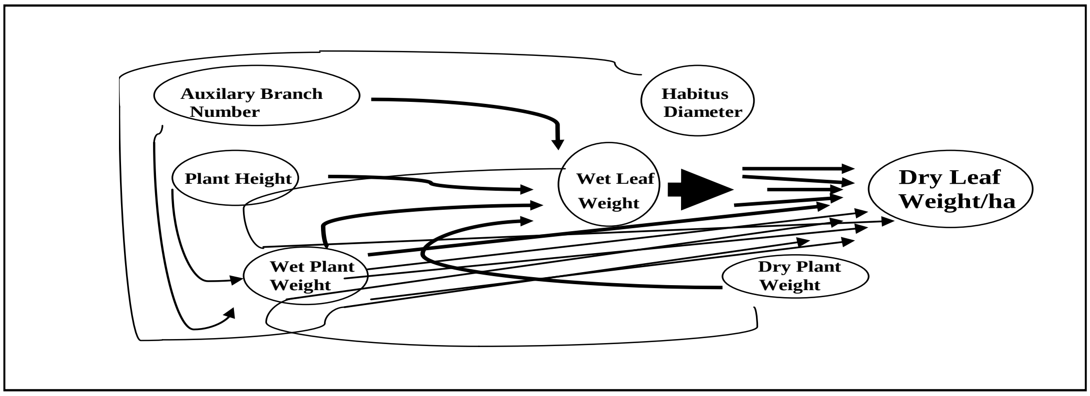

Figure 3. Dispersion of direct and indirect effects of characters on dry leaf weight.

4. Conclusions and discussion

Satureja genus, constituted of more than 280 species in the world, is largely extended in Mediterranean Region including Turkey (Satıl et al. 2008; Andi et al., 2011). Genetic variation among genotypes is an essential issue for genetic improvement of plants in *Satureja* breeding programmes (Ekiz, et al., 2006). Breeding programs have been initiated and developed in recent years. Determination the effective plant characters will play important role to increase breeding programs in which success in it highly depends on straightness and effectiveness of yield components. Results of statistical analyses showing effectual characters are given in Table 10.

Table 10. Results of statistical analyses showing effective characters.

Characters	Correlation	Multiple Regression	Best Subset Regression	Factor	Cluster	Path
Plant Height	✓					
Auxiliary Branch Number	✓	✓	✓	✓		
Habitus Diameter	✓					
Wet Plant Weight	✓	✓	✓		✓	✓
Dry Plant Weight	✓		✓	✓	✓	
Wet Leaf Weight	✓	✓	✓	✓	✓	✓

Analysis of six statistical analyses stressed that auxiliary branch number, wet plant weight, dry plant weight and wet leaf weight are found as the most important and efficacious characters for dry leaf weight in summer savory. Such characters could be used to guide future breeding studies and management of summer savory genotypes. Besides, they will create opportunity to increase success of selection summer savory improvement programs and to develop high yielding genotypes with high drug quality.

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